Interferometric inversion for passive imaging and navigation

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Final Report

REPORT DOCUMENTATION PAGE

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14. ABSTRACT

The PI analyzes the potential of using commercial digital TV or cellular communication signals in order to perform 1) source geolocation from a moving platform, and conversely 2) navigation of the moving platform from geolocated sources. This project aims at quantifying resolution (i.e., the expected length scales of accuracy of this recovery) and the scaling relations that explain those resolutions from first physical principles.

15. SUBJECT TERMS
Geolocation, navigation, array processing, direction finding, DOA, FDOA, resolution

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PI: Laurent Demanet
Department of Mathematics
Massachusetts Institute of Technology.

- Grant title: Interferometric inversion for passive imaging and navigation

- Grant number: FA9550-15-1-0078

- Period: Feburary 2015 - January 2017

- Research results:

  The PI is leading two collaborative research efforts in the area of signal processing for direction finding, geolocation, and navigation.

  First, we analyze the potential of using commercial digital TV or cellular communication signals in order to perform 1) source geolocation from a moving platform, and conversely 2) navigation of the moving platform from geolocated sources. In the context of a standard such as OFDM signals, the principles according to which recovery of positions and/or velocities is possible are called direction-of-arrival (DOA) and frequency-difference-of-arrival (FDOA). This project aims at quantifying resolution (i.e., the expected length scales of accuracy of this recovery) and the scaling relations that explain those resolutions from first physical principles. Progress was made on quantifying the scaling of resolution as a function of most of the parameters of interest: signal-to-noise ratio, clock offset, radial velocities (Doppler), angular velocities (aspect delta), heading errors, antenna positioning errors, and small-range effects, for DOA in the context of a single source (without needing to fit the source pulse). The resulting resolution scales are on the order of 1 to 5 m at 40 dB noise, and 1 to 5 m for each 10kHz of frequency offset. Work remains to address all these questions in the presence of multiple sources.

  Second, we design new methods of blind deconvolution based on convex programming, in settings where the performance of those methods can be mathematically understood and certified. Blind deconvolution is a major open question in signal processing, with applications among others in adversarial channel estimation when the incident pulse is unknown. In this reporting period, we considered the situation of "diverse inputs" where the impulse response is arbitrary, and the input signals are arbitrary members of known random subspaces. We provide theoretical and numerical evidence that recovery is possible with convex programming, at the information-theoretic limit (signal length much greater than subspace dimension), provided the number of inputs is logarithmic in signal length. These theoretical guarantees are the first of their kind for blind deconvolution with unconstrained impulse responses. (Previous results assumed subspace constraints for the impulse response). The results are now set to appear in IEEE Transactions on Information Theory.

  The PI has ties with AFRL and visited WPAFB in the summer of 2015. An intern at WPAFB, co-advised with Jason Parker, participated in the research effort.

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Laurent Demanet

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Arje Nachman

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Abstract

The PI is leading two collaborative research efforts in the area of signal processing for direction finding, geolocation, and navigation.

First, we analyze the potential of using commercial digital TV or cellular communication signals in order to perform 1) source geolocation from a moving platform, and conversely 2) navigation of the moving platform from geolocated sources. In the context of a standard such as OFDM signals, the principles according to which recovery of positions and/or velocities is possible are called direction-of-arrival (DOA) and frequency-difference-of-arrival (FDOA). This project aims at quantifying resolution (i.e., the expected length scales of accuracy of this recovery) and the scaling relations that explain those resolutions from first physical principles. Progress was made on quantifying the scaling of resolution as a function of most of the parameters of interest: signal-to-noise ratio, clock offset, radial velocities (Doppler), angular velocities (aspect delta), heading errors, antenna positioning errors, and small-range effects, for DOA in the context of a single source (without needing to fit the source pulse). The resulting resolution scales are on the order of 1 to 5 m at 40 dB noise, and 1 to 5 m for each 10kHz of frequency offset. Work remains to address all these

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